PATENT

Species 2: (elastomeric material) - claims 124, 141 (silicone), and claims 109-123, 128-140, and 142-209;

Species 3: (bonding activation) - claims 129, 135, and 154 (heat), and claims 109, 128, 133, and 150;

Species 4: (imparting conductivity) - claim 161, 174-175, and 184 (metallization), and claims 109, 160, and 183;

Species 5: (metal deposition) - claim 162 (sputtering), and claims 109, 160, and 161;

Species 6: (carbon deposition) - claims 169-171 (carbon in solvent), and claims 109, 160, and 167;

Species 7: (conductive dopants) - claim 184 (metal), and claims 109, 160, and 183; and

Species 8: (patterning conductive layer) - claims 177-181 (sacrificial masking), and claims 109, 160, and 176.

The Examiner is invited to contact the undersigned by telephone at 650 326-2400 x5423 in the event that a telephone conference would be of value in expediting prosecution of this case.

Respectfully submitted,

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VERSION SHOWING CHANGES MADE

109. A method of microfabricating an elastomeric structure, comprising:

microfabricating a first elastomeric layer;

microfabricating a second elastomeric layer;

positioning the second elastomeric layer on top of the first elastomeric layer; and

bonding a bottom surface of the second elastomeric layer onto a top surface of the first elastomeric layer.

110. The method of claim 109 wherein the first and second elastomeric layers are microfabricated by replication molding.

111. The method of claim 109 wherein the first and second elastomeric layers are microfabricated by laser cutting.

112. The method of claim 109 wherein the first and second elastomeric layers are microfabricated by chemical etching.

113. The method of claim 113 wherein the first and second elastomeric layers are microfabricated by sacrificial layer methods.

114. The method of claim 109 wherein the first and second elastomeric layers are microfabricated by injection molding.

115. The method of claim 109 wherein:

the first elastomeric layer is fabricated on a first micromachined mold having at least one raised protrusion which forms at least one recess in the bottom of the first elastomeric layer; and

the second elastomeric layer is fabricated on a second micromachined mold having at least one raised protrusion which forms at least one recess in the bottom of the first elastomeric layer.

116. The method of claim 115 wherein the first micromachined mold has at least one first raised protrusion which forms at least one first channel in the bottom surface of the first elastomeric layer.

117. The method of claim 116 wherein the second micromachined mold has at least one second raised protrusion which forms at least one second channel in the bottom surface of the second elastomeric layer.

118. The method of claim 117 wherein a bottom surface of the second elastomeric layer is bonded onto a top surface of the first elastomeric layer such that the at least one second channel is enclosed between the first and second elastomeric layers.

119. The method of claim 116 further comprising positioning the first elastomeric layer on top of a planar substrate such that the at least one first channel is enclosed between the first elastomeric layer and the planar substrate.

120. The method of claim 116 wherein a hermetic seal is formed between the bottom of the first layer and the top of the planar substrate.

121. The method of claim 109 further comprising:
microfabricating an nth elastomeric layer; and
bonding the bottom surface of the (n-1)th elastomeric layer onto a top surface of the nth elastomeric layer.

122. The method of claim 109 further comprising:
sequential addition of further elastomeric layers, whereby each layer is added by:
microfabricating a successive elastomeric layer; and
bonding the bottom surface of the successive elastomeric layer onto a top surface of the elastomeric structure.

123. A method of microfabricating an elastomeric structure comprising:

 

providing a first microfabricated elastomeric structure;

providing a second microfabricated elastomeric structure; and

bonding a surface of the first elastomeric structure onto a surface of the second elastomeric structure.

124. The method of claim 109 wherein at least one of the first elastomeric layer and the second elastomeric layer are fabricated from a material selected from the group consisting of:

elastomeric compositions of polyisoprene, polybutadiene, polychloroprene, polyisobutylene, poly(styrene-butadiene-styrene), the polyurethanes, and silicones.

125. The method of claim 109 wherein at least one of the first elastomeric layer and the second elastomeric layer are fabricated from a material selected from the group consisting of:

poly(bis(fluoroalkoxy)phosphazene) (PNF, Eypel-F), poly(carborane-siloxanes) (Dexsil), poly(acrylonitrile-butadiene) (nitrile rubber), poly(1-butene), poly(chlorotrifluoroethylene-vinylidene fluoride) copolymers (Kel-F), poly(ethyl vinyl ether), poly(vinylidene fluoride), poly(vinylidene fluoride – hexafluoropropylene) copolymer (Viton).

126. The method of claim 109 wherein at least one of the first elastomeric layer and the second elastomeric layer are fabricated from a composition selected from the group consisting of:

polyvinylchloride (PVC), polysulfone, polycarbonate, polymethylmethacrylate (PMMA), or polytertrafluoroethylene (Teflon).

127. The method of claim 124 wherein at least one of the first elastomeric layer and the second elastomeric layer are fabricated from a material selected from the group consisting of polydimethylsiloxane (PDMS) such as General Electric RTV 615, Dow Chemical Corp. Sylgard 182, 184, or 186, and aliphatic urethane diacrylates such as Ebecryl 270 or Irr 245 from UCB Chemicals.

 

128. The method of claim 109 wherein the first elastomeric layer has an excess of a first chemical species and the second elastomeric layer has an excess of a second chemical species.

129. The method of claim 128 wherein the elastomeric layers comprise thermoset elastomers which are bonded together by heating above an elastic/plastic transition temperature of at least one of the first and second elastomeric layers.

130. The method of claim 128 wherein the first and second chemical species comprise different molecules.

131. The method of claim 128 wherein the first and second chemical species comprise different polymer chains.

132. The method of claim 128 wherein the first and second chemical species comprise different side groups on the same type of polymer chains.

133. The method of claim 128 wherein the first chemical species forms bonds with the second chemical species when at least one chemical species is activated.

134. The method of claim 133 wherein the at least one chemical species is activated by light.

135. The method of claim 133 wherein the at least one chemical species is activated by heat.

136. The method of claim 133 wherein the at least one chemical species is activated by the addition of a third chemical species.

137. The method of claim 136 wherein the at least one chemical species diffuses through the elastomer structure.

138. The method of claim 128 wherein the first and second elastomeric layers are formed of different elastomeric materials.

139. The method of claim 128 wherein the first and second elastomeric layers are initially composed of the same elastomeric material, and an additional elastomeric material is added to one of the first and second layers.

140. The method of claim 128 wherein the first and second elastomeric layers are composed of the same component materials, but differ in the ratio in which the component materials are mixed together.

141. The method of claim 140 wherein each of the elastomeric layers is made of two-part silicone.

142. The method of claim 141 wherein each elastomeric layer comprises an addition cure elastomer system.

143. The method of claim 141 wherein the silicone comprises two different reactive groups and a catalyst.

144. The method of claim 143 wherein the first reactive group comprises silicon hydride moieties, the second reactive group comprises vinyl moieties, and the catalyst comprises platinum.

145. The method of claim 144 wherein each elastomeric layer comprises G.E. RTV 615.

146. The method of claim 145 wherein the first elastomeric layer is mixed with a ratio of less than 10A:1B (excess Si-H groups) and the second elastomeric layer is mixed with a ratio of more than 10A:1B (excess vinyl groups).

147. The method of claim 146 wherein the first elastomeric layer has a ratio of 3A:1B (excess Si-H groups) and the second elastomeric layer has a ratio of 30A:1B (excess vinyl groups).

148. The method of claim 128 wherein each of the elastomeric layers are made of polyurethane.

149. The method of claim 148 wherein the polyurethane comprises Ebecryl 270 or Irr 245 from UCB Chemicals.

150. The method of claim 109 wherein the first and second elastomeric layers are made of the same material.

151. The method of claim 150 wherein at least one of the first and second elastomeric layers are incompletely cured.

152. The method of claim 150 wherein both the first and second elastomeric layers comprise a crosslinking agent.

153. The method of claim 152 wherein the crosslinking agent is activated by light.

154. The method of claim 152 wherein the crosslinking agent is activated by heat.

155. The method of claim 152 wherein the crosslinking agent is activated by an additional chemical species.

156. The method of claim 150 wherein the elastomeric layers comprise thermoset elastomers which are bonded together by heating above an elastic/plastic transition temperature of at least one of the first and second elastomeric layers.

157. The method of claim 109 wherein the first and second layers are bonded by a layer of adhesive.

158. The method of claim 157 wherein the adhesive comprises an uncured elastomer which is cured to bond the first and second elastomeric layers together.

159. The method of claim 158 wherein the adhesive comprises the same material as at least one of the first or second elastomeric layers.

160. The method of claim 109 wherein at least one of the elastomeric layers further comprises a conductive portion.

161. The method of claim 160 wherein the conductive portion is made by metal deposition.

162. The method of claim 161 wherein the conductive portion is made by sputtering.

163. The method of claim 161 wherein the conductive portion is made by evaporation.

164. The method of claim 161 wherein the conductive portion is made by electroplating.

165. The method of claim 161 wherein the conductive portion is made by electroless plating.

166. The method of claim 161 wherein the conductive portion is made by chemical epitaxy.

167. The method of claim 160 wherein the conductive portion is made by made by carbon deposition.

168. The method of claim 167 wherein the conductive portion is made by mechanically rubbing material directly onto the elastomeric layer.

169. The method of claim 167 wherein the conductive portion is made by exposing the elastomer to a solution of carbon particles in solvent.

170. The method of claim 169 wherein the solvent causes swelling of the elastomer.

171. The method of claim 169 wherein the elastomer comprises silicone and the solvent comprises a chlorinated solvent.

172. The method of claim 167 wherein the conductive portion is made by electrostatic deposition.

173. The method of claim 167 wherein the conductive portion is made by a chemical reaction producing carbon.

174. The method of claim 160 wherein the conductive portion is made by:
patterning a thin layer of metal on a flat substrate;
adhering the elastomeric layer onto the flat substrate; and
peeling the elastomeric layer off the flat substrate, such that the metal sticks to the elastomeric layer and comes off the flat substrate.

175. The method of claim 174 wherein the adhesion of the metal to the flat substrate is weaker than the adhesion of the metal to the elastomer.

176. Method of claim 160 wherein the conductive portion is patterned.

177. The method of claim 176 wherein the conductive portion is patterned by masking a surface of the conductive portion with a patterned sacrificial material.

178. The method of claim 176 wherein the conductive portion is patterned by:
depositing a sacrificial material on one of the elastomeric layers,
patterning the sacrificial material,
depositing a thin coat of conductive material thereover, and
removing the sacrificial material.

179. The method of claim 176 wherein the conductive portion is patterned by masking the surface with a shadow mask.

180. The method of claim 179 wherein the conductive portion is patterned by:
positioning a shadow mask adjacent to an elastomeric layer;
depositing a thin coat of conductive material through apertures in the shadow mask; and
removing the shadow mask.

181. The method of claim 176 wherein the conductive portion is patterned by etching.

182. The method of claim 181 wherein the conductive portion is patterned by:
depositing a mask layer onto one of the elastomeric layers;
patterning the mask layer;
etching the conductive portion through holes in the mask layer; and
removing the mask layer.

183. The method of claim 160 wherein the conductive portion is produced by doping the elastomer with a conductive material.

184. The method of claim 183 wherein the conductive material comprises a metal.

185. The method of claim 183 wherein the conductive material comprises carbon.

186. The method of claim 183 wherein the conductive material comprises a conductive polymer.

187. The method of claim 183 wherein the elastomer used is inherently conductive.

188. The method of claim 160 further comprising sealing the microfabricated elastomeric structure onto a flat substrate, wherein the flat substrate comprises at least one conductive portion.

189. The method of claim 188 wherein the flat substrate is covered by an insulating layer.

190. The method of claim 54 wherein at least one of the first or second elastomeric layers comprises a magnetic portion.

191. The method of claim 190 wherein the magnetic portion is composed of an intrinsically magnetic elastomer.

192. The method of claim 190 wherein the magnetic portion is composed of an elastomer doped with a magnetic material.

193. The method of claim 192 wherein the magnetic dopant is a magnetically polarizeable material.

194. The method of claim 193 wherein the magnetic dopant is fine iron particles.

195. The method of claim 192 wherein the magnetic dopant is a permanently magnetized material.

196. The method of claim 195 wherein the permanently magnetized material is NdFeB or SmCo magnetized by exposure to a high magnetic field.

197. The method of claim 190 wherein pieces of magnetic material are relatively large compared with the size of the magnetic portion are incorporated into the elastomer.

198. The method of claim 197 wherein the magnetic material is a magnetically polarizeable material.

199. The method of claim 198 wherein the magnetic material is iron.

200. The method of claim 197 wherein the magnetic material is permanently magnetized.

201. The method of claim 200 wherein the permanently magnetized material is NdFeB or SmCo magnetized by exposure to a high magnetic field.

202. The method of claim 190 further comprising providing a structure capable of generating a switchable magnetic field, disposed adjacent to said magnetic portion, such that the application of said magnetic field to the elastomeric structure causes the generation of a force on the magnetic portion.

203. The method of claim 202 wherein the structure generating the magnetic field is a magnet coil.

204. The method of claim 202 wherein the structure generating the magnetic field is a substrate with at least one microfabricated magnet coil disposed thereon.